The Skill Content of Inter- and Intra-Industry Trade: Evidence for the United Kingdom

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Abstract: In this paper we investigate the relative importance of net exchanges of skills embodied in intra-industry and inter-industry trade for the UK's trade with some middle income countries. We also separately measure the net exchanges of skills embodied in vertical and horizontal intra-industry trade (IIT). We find that there are substantial factor exchanges involved in IIT, implying that traditional factor content studies may have seriously underestimated the actual factor content of total trade flows. This means that the adjustment effects of IIT may be greater than is often presumed. We also find, in line with theory, that vertical IIT involves similar net exchanges of labour of different skills to that of inter-industry trade, while horizontal IIT involves much smaller net exchanges of skills. JEL no. F11, F14
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1 Introduction

The notion that trade in goods reflects differences in countries' factor endowments has generated interest in measuring the "factor content" of trade. Traditionally this was done under the assumptions of the Heckscher–Ohlin model, where common technologies and factor price equalization implied that a country's input/output matrix could be employed to measure the factors used to produce both its imports and exports. There is a long tradition of finding apparently "paradoxical" evidence on the measured factor content of countries' trade using this method, and a range of rationalizations or explanations for the performance of factor content tests has been offered. Among these it is now widely recognized that the assumption of common technologies in the production of a given good may not hold.

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The growing significance of intra-industry trade (IIT) and the development of "new" trade theory models, where trade is based on firm specialization in varieties of differentiated products produced using similar technologies, raised the possibility that a substantial proportion of goods trade may involve no net factor trade at all. However, it is now recognized that IIT could have a factor content if varieties are vertically differentiated and country specialization within industries is determined by relative factor abundance. The early empirical work tended to presume that IIT was predominantly in similar or non-vertically differentiated goods and sought to test models where technologies in the differentiated goods sector were assumed to be identical across countries. In contrast to earlier empirical support for such models of IIT, Hummels and Levinsohn (1995) found, for the United States' bilateral trade over the period 1962–1983 having controlled for country fixed effects, that the share of IIT in the United States' gross trade increased as capital-labour endowment differentials with its trading partners increased. This has encouraged researchers to investigate whether the presumption about the relative unimportance of IIT in vertically differentiated goods was valid. A number of studies (Greenaway et al. 1994, 1999 and Durkin and Krygier 2000 for example) have concluded that in fact IIT in vertically differentiated goods is the dominant form of IIT.

In this paper we follow the suggestion of Davis and Weinstein (2001), distinguishing the factor content of matched IIT and studying the relative importance of this vis à vis that of inter-industry trade. In doing this we try to answer questions that differ from those posed by most other factor content studies.[1] Specifically, we explore the importance of the net exchanges of skills embodied in IIT relative to total trade and to inter-industry trade flows. We question if, for the same amount of trade, matched IIT embodies smaller net exchanges of factor services. We also ask if the factor content of vertical intra-industry trade embodies different net exchanges of factors than that of horizontal intra-industry trade. And, related to this, we ask if the factor content of vertical intra-industry trade is in the same direction and has the same intensity as that of inter-industry trade.

[1] Most factor content studies focus either on testing the validity of the original model or testing this against alternative specifications that improve the match between the predicted and measured factor content. In doing this the authors are asking questions of the type: "What simple modifications can be found to improve the performance of the factor endowments model?", or "What is the best specification of technology and demand to study the role of factor endowments in explaining trade?", or even "What is the contribution of the different components (endowments, technology, demand, imperfect competition, etc.) in explaining trade in goods and in factor services?".

This work extends Davis and Weinstein (2001) in a number of ways, by using more disaggregated data on industries and by differentiating between the skill types of labour. This allows us to explore not only the skill content of inter- and intra-industry trade, but also the skill content of intra-industry trade in horizontally and vertically differentiated goods. The resulting empirical evidence allows us to comment upon both the theoretical and policy debate relating to intra-industry trade and specialization. Our finding that vertical IIT does involve substantial net exchanges of skill types can be interpreted as positive, indirect support for the factor proportions model of IIT (Falvey 1981; Falvey and Kierzkowski 1987) arising from inter-country differences in labour skill endowments and differences in product qualities due to differences in factor (skill) intensities of production. In turn, the evidence of similar net exchanges of labour skills for inter- and vertical intra-industry trade, but of small net factor exchanges for horizontal IIT, is important for assessing the Smooth Adjustment Hypothesis (SAH); horizontal intra-industry specialization being likely to involve smoother adjustment than vertical intra-industry specialization.

The remainder of the paper is organized as follows. The methodology used to measure factor (skill) content is set out in the next section. We begin with the standard approach for measuring skill content of bilateral net trade, assuming industries produce homogeneous goods, and using a single input/output matrix. We then modify this to allow for (national) technology differences. At this point we switch to the alternative assumption that firms within industries are producing differentiated products that (may) require different mixes of skill inputs. Calculating the actual factor content of bilateral trade in such circumstances requires input/output matrices of both trading partners. We suggest two ways in which this might be calculated. Section 3 then considers implementation and data issues involved in our application of the methods described in the preceding section to UK trade. Evidence on the skill content of the UK's net or inter-industry trade is presented in Section 4. Section 5 reports comparable evidence on intra-industry trade and its components (vertical and horizontal IIT). Our conclusions are set out in Section 6.

2 Measuring Factor Content

Studies that use a factor content approach traditionally consider the input matrix of factor requirements of only one country to measure factor content of both imports and exports. This approach assumes that products are homogeneous, that there are identical technologies in all countries and that trade leads to factor price equalization. The input requirements of exports and imports would then be identical.[2] In this context the net factor content of IIT is zero because the factors embodied in symmetric trade flows are matched. The approach proposed here allows different varieties of differentiated products to have different input requirements. Then if the mix of varieties produced in each industry differs between any two countries, imports and exports of the same industry may have different input requirements, even if the technology of producing any variety is the same in both countries.[3] In this setting, intra-industry trade flows may embody important net exchanges of different factors.

In practice, our method of using each country's input requirements matrix to calculate the factor content of its exports, follows that suggested by Deardorff (1982) and Helpman (1984), and used in the recent papers of Hakura (1999, 2001) and Davies and Weinstein (1998, 2001) in a context of non factor price equalization (FPE). We begin with the Heckscher–Ohlin–Vanek (HOV) equation[4] explaining the factor content of bilateral trade between two countries, which we label P and U since we later apply this method using factor requirements matrices for Portugal and the United Kingdom:

$$F_{jUP} = E_{jU} - s_U(E_{jU} + E_{jP}), \tag{1}$$

with

$$F_{jUP} = A_U NT_{UP}. \tag{2}$$

Here F_{jUP} is the embodied trade in factor j measured from the direct requirements[5] of the bilateral trade between countries U and P, E_{ji} is the

[2] This is true both in the context of the Heckscher–Ohlin model, which did not predict the existence of IIT, and in monopolistic competition general equilibrium models (Helpman and Krugman 1985) which assume that all intra-industry trade is horizontal, and production technologies in the differentiated goods sector are identical across countries.

[3] Davis and Weinstein (2001) assume that the difference in relative factor use in any two countries results from different technologies and factor prices across countries, while we are considering that it is the result of the existence of product differentiation.

[4] Strictly speaking the bilateral factor content of trade cannot be predicted under the strict assumptions of the HOV setting, namely with factor price equalization, and equation (1) is the result of applying the HOV equation in a world where FPE does not apply and follows the "bilateral comparison" used by Davis and Weinstein (2001). We include it simply to compare the results obtained in this way with those obtained when other specifications are chosen.

[5] Several authors (Staiger 1986; Maskus et al. 1994; Bowen et al. 1998) discuss whether only direct factor requirements should be considered in the calculations of the factor con-

endowment of factor j in country i, s_i is the world income share of country i, and A_U is the input requirements matrix used (which is implicitly assumed to be the same in both countries). The vector of trade flows considered in this case is only that of net trade flows in bilateral trade between the two countries (NT_{UP}).

This approach can be modified to allow for (Hicks neutral) technological differences between countries. Introducing this "correction" yields:

$$F_{jUP} = E_{jU} - s_U(E_{jU} + \delta_P E_{jP}), \tag{3}$$

where δ_P is the Hicks neutral productivity parameter for country P, and δ_U has been normalized at unity. Here the endowments are transformed by productivity differences in such a way that they become equivalent in terms of their production potential.[6]

Once we drop the assumption that industries produce homogeneous goods, and allow imports and exports to represent different products, produced using different technologies, then the domestic input matrix does not capture the actual factor content of imports. To apply this differentiated product approach we therefore need measures based on two different input requirements matrices. For bilateral trade between U and P the equation is:

$$(AF_{jUP})/\psi_{UP} = [E_{jU} - s_U(E_{jU} + E_{jP})]. \tag{4}$$

With the actual factor content being measured by:

$$AF_{jUP} = A_U X_{UP} - A_P M_{UP}, \tag{5}$$

where X_{UP} and M_{UP} are, respectively, exports of U to P and imports of U from P represented in different types of trade flows (net trade; matched

tent, or also the factors used in the intermediates (indirect factor requirements). Maskus et al. (1994), following Staiger (1986), argue that direct requirements are more appropriate for the case of small open economies that trade intermediate goods freely at world prices, since in these cases a large amount of the inputs will come from the trading partners. We accept this position and measure only the direct factor content of UK trade. This is also convenient given data constraints on measuring indirect factor requirements at the level of trade disaggregation used here. See Trefler and Chun Zhu (2005), however, for a discussion of how using direct inputs only may affect the measurement of factor content.

[6] Here the adjustment consists of transforming the available man years of different countries into efficiency equivalent units of man years. A range of proxies were considered to capture productivity differences, including differences in output per worker and per capita GDP. The results reported use differences in average wages in manufacturing across the countries. Results for alternative means of correcting for productivity differences are available from the authors on request.

intra-industry trade; horizontal and vertical intra-industry trade). In (4) each type of trade flow is scaled by the parameter ψ_{UP}, which is the proportion of each type of trade flow in total bilateral trade.[7] Equation 4 can also be subject to a productivity correction yielding:

$$(AF_{jUP})/\psi_{UP} = [E_{jU} - s_U(E_{jU} + \delta_P E_{jP})]. \tag{6}$$

A technique that can only be applied to a particular bilateral trade flow is of rather limited interest, however. Ideally we would like to consider the factor content of total trade for each country of interest. An obvious problem in attempting to measure the factor content of all bilateral trade using equation (5), is that information on input requirements in *all* of a country's trading partners is unavailable. We offer two "solutions" for this, both of which are applied below. The first is to apply a "representative" matrix for all countries at the "same level of development". Thus, for example, we could apply, say, the UK matrix for all high income developed (HID) countries and the Portuguese matrix for all middle income developed (MID) countries. The second solution is to approximate these requirements using information about the (differences in) the matrices that are available. For example, we can estimate the matrix for another country (R say) using a linear combination of A_P and A_U where the weights are based on the per capita GDPs of the three countries (i.e. y_j, $j = R$, P and U). Thus

$$A_R = \theta_R A_U + [1 - \theta_R]A_P = \theta_R[A_U - A_P] + A_P, \tag{7}$$

where A_R is the estimated input requirements matrix for country R. Assuming that $y_U - y_P > 0$, the weighting parameter θ_R is given by:

$$\theta_R = [y_R - y_P]/[y_U - y_P], \text{ for all countries where } y_R - y_P > 0;$$

and

$$\theta_R = [y_R - y_P]/[y_U - y_R], \text{ for all countries where } y_R - y_P < 0.$$

This implies $\theta_U = 1$, $\theta_P = 0$, and a country with a GDP per capita that is exactly halfway between that of Portugal and the UK will have $\theta_R = 1/2$. For countries with an income per capita below that of Portugal the weighting

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[7] The gross trade between U and P ($X_{UP} + M_{UP}$) is decomposed into net trade ($|X_{UP} - M_{UP}|$), and matched trade ($2\min\{X_{UP}, M_{UP}\}$). Further matched trade is decomposed into matched trade in horizontally differentiated and vertically differentiated goods using the method used by Greenaway et al. (1994). Each component is expressed relative to gross trade to provide the relevant scaling parameter (ψ_{UP}) in equation (4).

parameter assumes a negative value,[8] while for countries where GDP per capita is above that of the UK the value will exceed unity.[9] The estimated matrix A_R then replaces A_P in the relevant bilateral factor content estimation.

The assumption underlying this approach is that factor requirements of each industry are similar in countries with similar per capita GDPs. Extending this line of thought we use the Portuguese input matrix to calculate skill requirements of UK's imports from both the MID and developing countries. We acknowledge that there may be important differences between input requirements of these countries and Portugal, particularly for developing countries,[10] but we argue that this should give us better estimates of input requirements of the UK's imports from these countries than those obtained if the UK matrix was used. Following the same logic, we will also use the UK input requirements matrix to calculate the skills embodied in exports of other HID countries.[11]

3 Implementation and Data Sources

To implement our alternative factor content methods we need data on trade and skill requirements for a consistent classification of industries and labour skills across countries. For industries we use a classification into 210 industries based on the 4-digit SIC (Standard Industrial Classification) categorization. Of the 262 manufacturing industries at this level of disag-

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[8] For the countries with a GDP per capita lower than Portugal's, the parameter θ varies between 0 and -0.7, since the Portuguese GDP per capita is about 70 per cent of that of the UK. In this case the weight on the Portuguese matrix is higher than unity, while the weight on the UK matrix is negative. Nevertheless, since the Portuguese matrix has, in general more workers per unit of production (reflecting lower productivity) the combination of the Portuguese matrix multiplied by more than the unity $(1 - \theta)$ more than compensates for the subtraction of the UK matrix multiplied by the a number smaller than one θ.

[9] The transformation presented here follows the tradition of Trefler (1993; 1995) of admitting that the input requirements of each country are linked to GDP per capita.

[10] The use of the Portuguese input requirements may overestimate the net exports of the lower skilled categories for some of the middle income countries with higher level of development than Portugal (such as Spain), and most probably these will also underestimate the unskilled labour content of the exports of the developing countries.

[11] Note that this procedure is original but follows a tradition of several studies that considered similar hypothesis for different situations. For example Trefler (1995) considered two groups of countries with different specifications of differences in technology for each group of countries. Davis et al. (1997) also considered two groups of regions, those of Japan where he admitted that FPE applies and the rest of the world.

gregation, 165 were taken as the given SIC(4) categories. But to match this with trade data from the SITC (Standard International Trade Classification) and the occupations and production data from the Portuguese CAE (similar to NACE/Clio) some sectors had to be aggregated. So the other 97 SIC categories were aggregated into 36 industries.[12]

Data on industrial employment by occupation and qualifications was obtained from the Data Archive Labour Force Survey for the UK, and from the Employment and Labour Statistical Office "Quadros de Pessoal" database, for Portugal. Most of the 89 occupations described in the Portuguese classification (CNP) at the 3-digit level are similar to the 74 occupations in other studies (e.g. Webster 1993) based on the UK Labour Force Survey Standard Occupational Classification (SOC). In many cases the higher number of categories of the Portuguese classification corresponds only to a division of the SOC categories into two or more CNP categories, posing no problem to matching the two classifications. But other cases were more complex, resulting in the need to aggregate some labour categories, in order to match the Portuguese and the SOC classifications. This generated 59 different labour categories (based on the SOC classification), which were then gathered into 4 categories that correspond to groups of different skill levels. There is no single agreed-upon method of classifying workers according to skill level. The simplest approach is just to consider the separation into two categories (i.e. skilled and unskilled), but other studies consider from 5 to 9 different labour categories.[13] Here we follow the labour economics literature that classifies the level of skills of occupational groups by matching occupational data with education and wage information, e.g. Howell and Wolf (1991), Sachs and Shatz (1994), Berman et al. (1994). Howell and Wolf (1991) relate skills to data on education and earnings, concluding that there are strong correlations between both education and earnings and the skills of each occupation. Table 1 presents our grouping of occupational categories into 4 different skill levels.[14]

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[12] Details of the matching of are available from the authors on request.

[13] The two studies that report results for a larger number of labour categories also adopt different criteria for aggregating these: Webster (1993) reports the factor content results for 35 different occupational categories and for 5 or 9 groups where these are gathered, while Maskus et al. (1994) report results for 74 occupations gathered in 8 different groups.

[14] Winchester et al. (2006) have recently developed a new classification for UK skills using educational attainment.

Table 1: *Grouping of Occupational Categories into Skill Levels*

Skill level	Occupational groups	Number of categories		Percentage with a degree		
			Exceptions[a]	Mean	Min.	Max.
1	2 Professional occupations	9	1(2)	67.28	42.20	94.04
2	3 Associate prof. & tech. occupations	10	1(1)	26.59	13.31	42.92
	1 Managers and administrators	9	2(3)	21.75	6.46	36.42
3	7 Sales occupations	5	1(2) 1(4)	8.58	2.38	18.18
	4 Clerical, secretarial occupations	8	1(4)	5.88	2.25	10.28
	6 Personal, protective occupations	9	4(4)	3.75	0.46	8.82
4	5 Craft and related occupations	10	2(3)	2.21	0.42	5.01
	8 Plant and machine operatives	10	1(3)	1.91	0.61	4.17
	9 Other occupations	7	1(3)	1.69	0.70	3.17
	Total	77	15	16.15	0.42	94.04

[a] Number of occupations in the group that are out of the rank order for the skill level. In parentheses are the skill levels to which these categories should belong.

4 Evidence on the Skill Content of Trade

We start by applying the factor content methodology in the traditional way, using the input requirements matrix of one country to measure the skills embodied in both imports and exports, to calculate the skill content of its net exports. Then we compare these results with those when measured factor content is corrected for productivity differences. Later we compare these with the measures where the matrix of more than one country is considered.

The services of labour of different skill levels embodied in UK net exports measured following the traditional approach (equations 1 and 3) are presented in Table 2 as a share of total consumption requirements. When measured this way, labour net exports in multilateral trade are relatively small compared with labour consumption requirements, ranging between 0.3 per cent and 3 per cent in 1995.[15] The UK is importing the services of 360 thousand workers, which corresponds to less than 1.5 per cent of total

[15] Total trade between the UK and all the countries considered in the present study—8 HID European countries plus the United States and Japan, and 27 MID and developing countries.

Table 2: *Skill Content of UK Net Exports*[a]*—Traditional Approach (per cent)*

	High skilled	Medium skilled	Clerical	Production
No productivity adjustment	0.34	−0.97	−0.67	−2.96
With productivity adjustment	0.58	0.09	−0.08	−0.75

[a] Net exports of services of labour in each skill level group divided by its apparent consumption requirements. Trade between the UK and 38 countries for 1995.

consumption requirements and about 7 per cent of manufacturing industry employment.

In 1995, the UK was a net importer of all labour types except high skilled labour. When imports and exports are corrected for differences in productivity the UK becomes an exporter of labour of the two higher skill level groups (high and medium skilled) and a net importer of the two lower ones (clerical and production workers).[16]

These results are consistent with those expected for a developed country. Similar evidence was obtained by Bowen et al. (1987), in which the UK is revealed to be more abundant in the high skilled labour category than in low skilled labour groups. The evidence obtained by Katrak (1982) also suggests a comparative advantage in more skilled labour. But contradictory evidence can be found in other studies. Crafts and Thomas (1986) and Oulton (1993) conclude that the UK is scarce in high skilled relative to low skilled labour.

We now present factor content evidence for UK's net or inter-industry trade when the product differentiation approach is applied. Table 3 presents these for different specifications of the product differentiation approach. Matrices based on Portuguese input requirements are used to calculate the factor content of middle income and developing countries' exports to the UK, which is then added to the measured factor content of the UK with the other developed countries, measured according to the UK matrix or the estimated matrices for both the developed and developing countries.

[16] The ratios of net exports to consumption requirements can be used to comment on sources of comparative advantage. Table 2 reveals that the UK had its strongest comparative disadvantage in the lower skilled group (production), while the high skilled workers are revealed to be the relatively more abundant skill level group.

Table 3: *Skill Content of UK Net Trade*[a]*—Product Differentiation Approach (per cent)*

	High skilled	Medium skilled	Clerical	Production
Using UK & Portuguese matrices	0.50	−0.82	−1.28	−11.38
Using UK & Portuguese matrices (productivity adjusted)	1.24	0.36	−0.87	−7.2
Using estimated matrices	1.06	0.18	−2.45	−16.37
Using estimated matrices (productivity adjusted)	1.28	0.74	−1.69	−10.26

[a] Net exports of services of labour in each skill level group as a percentage of its apparent consumption requirements. Trade between the UK and 38 countries in 1995.

The use of the product differentiated approach has a strong influence on the magnitude of total net skill exports relative to their consumption. This is especially true in the case of unskilled labour. The UK's net imports of this labour category are almost 4 times higher when the effects of product differentiation are taken into account using the Portuguese input requirements matrix. The effect is even larger when one compares the results that correct for neutral differences in productivity. If we assume that the Portuguese and UK matrices provide reasonable estimates of the input requirements for the two groups of countries and that the difference between the two matrices are attributable predominantly to product differentiation, then the UK is importing services of unskilled labour embodied in its manufacturing trade that correspond to 11.4 per cent of its consumption requirements and almost 40 per cent of unskilled workers employed in the manufacturing industry. Using the estimated matrices increases these and suggests that the use of the differentiated product approach improves the way in which endowments explain factor content, and contributes to reducing the "missing trade" phenomenon.

5 The Skill Content of Intra-Industry Trade

We now apply the same analysis to estimate the net exchanges of factors embodied in intra-industry trade. To measure the factor content embodied in intra-industry trade flows one needs at least two different input requirements matrices. It would not make much economic sense to use differences in the Portuguese and UK matrix to estimate factor content between two HID countries (e.g. the UK and France). We focus therefore on UK trade with some MID countries.

Table 4 presents the Grubel–Lloyd bilateral intra-industry trade indexes for trade between the UK and different groups of countries.[17] It also reports the decomposition into IIT in vertically and horizontally differentiated goods according to the unit value dispersion method (+/− 15 per cent) proposed by Greenaway et al. (1994, 1995). In the case of vertical IIT the Table 4 reports the decomposition into vertical IIT where the UK is the higher quality exporter (Type I) and where it is the lower quality exporter (Type II).[18]

Table 4: *Percentage Share of Intra-Industry Trade between the UK and Groups of Trade Partners*

Groups of Countries	Total IIT[a]	Horizontal IIT[b]	Vertical IIT high quality $P_X/P_M > 1.15$	Vertical IIT low quality $P_X/P_M < 0.85$
All 38 countries	46.7	15.4	20.5	10.8
HID countries	66.8	25.6	25.8	15.4
MID countries	46.3	8.2	25.1	13.0
Developing countries	19.7	2.9	14.6	2.1

[a] The Grubel–Lloyd index for the bilateral trade between the UK and the different partner countries. The IIT indexes were calculated for the classification used here (the manufacturing industry is divided in 201 different categories based on the SIC 4-digit classification). — [b] Horizontal and vertical IIT were calculated at the 5-digit SITC and then aggregated to each SIC category.

Table 5 presents the measured skill content of different types of trade flows, measured using the differentiated product approach without correcting for differences in productivity, for trade between the UK and MID

[17] The 38 countries considered represent about two thirds of UK trade, and are classified as follows (a) HID countries: France, Germany, Belgium, the Netherlands, Luxemburg, Denmark, Finland, Norway, Sweden, the United States, Japan; (b) MID countries: Cyprus, the Czech Republic, Greece, Portugal, Slovenia, South Korea, Spain; and (c) developing countries: China, Brazil, Bulgaria, Colombia, Costa Rica, Egypt, Estonia, Hungary, Malaysia, Latvia, Lithuania, the Philippines, Poland, Romania, Slovakia, Thailand, Mexico, Russia, Turkey, the Ukraine.

[18] This decomposition method has been criticized by Nielsen and Lüthje (2002), but is widely used and is more tractable than the alternatives that have been suggested.

Table 5: *Skill Content of UK Inter- and Intra-Industry Trade*[a] *with Some MID Countries (per cent)*

Without productivity adjustment	High skilled	Medium skilled	Clerical	Production
INTER-industry trade	0.11	0.06	−0.18	−1.63
INTRA-industry trade	0.03	−0.08	−0.10	−1.79
Horizontal IIT	0.00	0.01	0.01	−0.19
Vertical IIT Type I (VTX/VTM > 1.15)	0.02	−0.06	−0.06	−1.31
Vertical IIT Type II (VTX/VTM < 0.85)	0.01	−0.03	−0.05	−0.29

[a] Net exports of services of labour in each skill level group divided by its apparent consumption requirements.

countries. We used the Portuguese matrix to calculate skill requirements of the imports and the UK skill requirements matrix for the UK exports involved in each type of trade flow.[19] Again, the measured skill content is divided by the factor requirements of consumption. The values are relatively small as is traditional in factor content studies, although in the present case one has to recognise that we are accounting for only about 12 per cent of the UK's trade. Nonetheless, IIT does involve non-negligible net exchanges of skill types.

Following Davis and Weinstein (2001) we also present the factors embodied in each type of trade flow divided by the exchanges of factors embodied in total trade (Table 6). The results show that an important proportion results from IIT. For medium skilled labour and low skilled production workers, the net exchanges of factors included in IIT are larger than those caused by inter-industry trade between the UK and MID countries. Indeed the share of the skill content embodied in vertical IIT (Type I) is higher than its share in total trade (see Table 4) even when adjusted for productivity differences. By contrast the share of net exchanges of factors embodied in horizontal IIT is much smaller than its share in total trade. Encouragingly also the factor services embodied in horizontal IIT are not similar to those embodied in net trade or vertical IIT.

[19] The skill requirements of the production of one million dollars of exports in each industry were considered to differ between the UK and the MID countries, but for each sector and country the requirements of producing one million dollars of exports are measured in the same way for the different types of trade flows.

Table 6: *Skill Content of Intra-Industry Trade as a Share of Total Skill Content of UK Trade with Some MID Countries (per cent)*

Without productivity adjustment	High skilled	Medium skilled	Clerical	Production	Average
INTER-industry trade	78.6	−41.3	64.0	47.6	37.2
INTRA-industry trade	21.4	58.7	36.0	52.4	42.1
Horizontal IIT	0.0	−6.7	−4.2	5.5	−1.4
Vertical IIT Type I high quality	14.3	44.0	21.9	38.4	29.6
Vertical IIT Type II low quality	7.1	21.3	18.4	8.5	13.8

The results in Table 5 are based on using Portuguese "technology" to represent that in the MID countries. We report, in Table A1 in the Appendix, on the comparable skill content measures when estimated technologies are used for the same set of countries. The pattern of measured skill content is very similar, though the skill content of inter-industry and vertical IIT is larger. In the Appendix the two methods for proxying technology are applied also to a broader set of countries that includes developing countries. Table A2 gives the results that are comparable with Table 5, and Table A3 the results that are comparable with those in Table A1. Again using estimated technologies increases the degree of technological diversity within the group of countries and increases the measured skill content of trade. The pattern of the results (across trade types and skill categories) is however generally in line with those for the MID countries only.

Some experimentation was also undertaken for the case where a wider (+/− 25 per cent) price dispersion criterion is used to decompose IIT into vertical and horizontal IIT. Although this increases the share of trade classified as horizontal IIT (and reduces that classified as vertical IIT), the relative magnitudes of the net exchanges embodied in the two types of IIT was only marginally affected. Our conclusions concerning the relative skill content of vertical and horizontal IIT do not appear, therefore, to be very sensitive to the decomposition criterion used.

Our findings on the relative magnitude of the skill content of net trade and IIT have some interesting implications. First, they suggest that the factor content of intra-industry trade may account for an important part of "missing trade". They may also explain why versions of the endowments model that only consider net trade flows tend to fail to get a match between the signs of measured and predicted factor content. Further, this evidence is clearly at odds with the widely accepted Chamberlinian–Heckscher–Ohlin model that separates trade into that explained by differences in endowments (inter-industry trade), and that explained only by product differentiation and scale economies. The fact that an important part of net exchanges of factors are embodied in matched trade flows and that these are in the same direction as that predicted by factor abundance and inter-industry trade suggests that factor endowments are playing a significant role in explaining intra-industry trade flows.

Most of the net exchanges of labour services embodied in IIT result from vertical IIT flows. In particular vertical IIT of Type I (where the UK is specialized in exporting varieties of high quality) accounts for more than two thirds of the actual factor content embodied in intra-industry trade flows. On average intra-industry trade flows contribute 42 per cent of the measured factor content of trade, while inter-industry trade contributes 37 per cent. Note, nevertheless, that these shares are much influenced by the medium skilled labour category for which the net factor content of trade is very low and different types of trade flows offer contradictory contributions for the measured net exports of services of medium skilled workers. More clear is the relative importance of vertical IIT and horizontal IIT, with the former being responsible for an important contribution of measured factor content while the latter, as would be expected from the monopolistic competition model, gives a very small contribution.

The introduction of corrections for productivity differences has the effect of diminishing the proportion of factor content attributed to IIT flows (see Table 7). Correcting for productivity differences tends to reduce the amount of labour embodied in imports from MID countries (to compensate for lower productivity). This affects the factor content of both inter- and intra-industry trade. But the evidence suggests that IIT flows are more affected than inter-industry trade flows by this correction. Nonetheless, IIT flows still embody 38 per cent of the average net exchanges of skills.

This is particularly important for the low skilled production workers for which the net exchanges of factors attributed to inter-industry trade were less than 50 per cent, before correcting for differences in productivity, and more than 70 per cent when measured factor content is corrected for productivity differentials. This result means that IIT is still an important conduit of net exchanges of factors, but with somewhat more limited importance than indicated by the first estimates and suggested by Davis and Weinstein (2001). They argue that "in half of the rich OECD countries in our sample, intra-

Table 7: *Skill Content of Intra-Industry Trade as a Share of Total Skill Content of UK Trade with Some MID Countries—Alternative Estimates (per cent)*

Without productivity adjustment	High skilled	Medium skilled	Clerical	Production	Average
INTER-industry trade	56.1	49.1	71.1	70.5	61.7
INTRA-industry trade	43.9	50.9	28.9	29.5	38.3
Horizontal IIT	3.7	−3.4	−3.3	2.0	−0.3
Vertical IIT Type I high quality	27.6	37.0	24.8	19.5	27.2
Vertical IIT Type II low quality	12.7	17.4	7.4	7.9	11.3

industry trade is more important in the net import and export of factor services" (Davis and Weinstein 2001: 17). They consider total labour and capital as factors, but do not correct for productivity differences. They also use a more aggregated industry classification than this study (21 rather than the 201 industries). With greater aggregation there is greater scope for within industry variation in skill content.

6 Conclusions

Factor content studies traditionally measure the factor content of net trade flows, assuming factor requirements are the same world wide and appropriately represented by one country's (usually the US) technology matrix. Recent studies depart from this approach. Starting with Hakura (1999) and Davis and Weinstein (1998), a small number of studies consider actual input requirements matrices of more than one country to measure factor content of total trade. These have revealed that net factor exports are much larger than indicated by the traditional approach. The evidence in this paper reinforces and confirms this. But, we go further, by placing the factor exchanges embodied in matched (intra-industry) trade flows at centre stage, and by using disaggregated data on industries. Indeed our analysis emphasizes the importance of taking into account the effects of product and skill differentiation when studying the role of factors in trade.

When we applied the differentiated product factor content approach our results suggest that former studies, based on the traditional approach, may have seriously underestimated the actual factors embodied in total trade flows. We find that UK imports of low skill production workers can be up to 4 times higher when the effects of product differentiation are taken into account. This means that the adjustment effects of trade may have been underestimated. It also suggests that the role of trade in explaining changes in the wage gap between skilled and unskilled labour may be more significant than suggested in the empirical literature.[20] This happens for two reasons. Firstly, the factor requirements of net imports are not the same as the requirements of the domestic production they are replacing. And secondly, IIT involves important net exchanges of factors, in particular in trade with the MID countries. Vertical IIT involves similar net exchanges of labour of different skill levels to that of inter-industry trade. By contrast, horizontal IIT flows involve smaller amounts of net exchanges of labour of different skill levels than an equivalent amount of inter-industry trade or vertical IIT.

This evidence has several implications. First, it confirms the importance of the distinction between matched trade in horizontally and vertically differentiated products. It seems to be as important as the distinction between inter- and intra-industry trade. Second, it is consistent with the assumptions of models of vertical and horizontal IIT. Vertical IIT appears to include exchanges of factors that are in accordance with the predictions of a skill version of the factor proportions model. The fact that exchanges of labour of different skill levels embodied in horizontal IIT are almost matched its consistent with the assumptions of monopolistic competition models that suggest these trade flows are explained by scale economies and product differentiation and not differences in factor endowments. Third, this evidence shows that IIT flows can involve the same type of net exchanges of factors as inter-industry trade, when they include the exchange of vertically differentiated products. This is contrary to the assumptions of the IIT smooth adjustment hypothesis. Nevertheless, a weak version of this hypothesis, restricted to horizontal IIT is coherent with the results. Horizontal IIT does seem to involve only small net exchanges of labour of different skill levels. This may be seen as indirect evidence that less factor market disruption occurs when matched trade expansion in horizontally differentiated products dominates than when unmatched trade or vertical IIT trade expansion prevails.

Finally by showing that vertical IIT trade involves significant net exchanges of factors while horizontal IIT does not, the evidence reported in this paper suggests that differences in factor requirements of differentiated products might be a more important cause for inter-country differences in

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[20] For a review of this literature see Slaughter (1999)

factor requirements than international differences in technology or non-equalization of factor prices across countries.[21]

Appendix

Table A1: *Skill Content of UK Inter- and Intra-Industry Trade with Some MID Countries*[a]*—Using Estimated Matrixes*[b]

Without productivity adjustment	High skilled	Medium skilled	Clerical	Production
INTER-industry trade	0.41	0.31	−0.27	−1.66
INTRA-industry trade	0.28	0.06	−0.20	−1.97
Horizontal IIT	0.01	0.01	0.00	−0.20
Vertical IIT Type I high quality	0.20	−0.01	−0.13	−1.48
Vertical IIT Type II low quality	0.07	0.05	−0.07	−0.30

[a] Trade between the UK and 7 MID countries in 1995. Net exports of services of labour in each skill level group as a percentage of its apparent consumption requirements. — [b] According to the method defined above in equation (7).

Table A2: *Skill Content of UK Inter- and Intra-Industry Trade with some MID and Developing Countries*[a]

Without productivity adjustment	High skilled	Medium skilled	Clerical	Production
INTER-industry trade	0.26	−0.10	−0.60	−6.85
INTRA-Industry trade	0.07	−0.12	−0.20	−2.97
Horizontal IIT	0.01	0.01	0.00	−0.30
Vertical IIT Type I high quality	0.05	−0.09	−0.14	−2.25
Vertical IIT Type II low quality	0.01	−0.03	−0.06	−0.42

[a] Trade between the UK and 27 MID and developing countries in 1995. Net exports of services of labour in each skill level group as a percentage of its apparent consumption requirements. The results presented in this table use the matrix of Portugal to calculate the factor requirements of each of the trading partners of the UK, following equation (5).

[21] This finding is consistent also with evidence found by Schott (2001) that the price of US imports are positively correlated with the per capita income and capital abundance of their country of origin.

Table A3: *Skill Content of UK Inter- and Intra-Industry Trade with Some MID and Developing Countries*[a]*—Using Estimated Matrixes*[b]

Without productivity adjustment	High skilled	Medium skilled	Clerical	Production
INTER-industry trade	0.76	0.30	−1.38	−9.24
INTRA-industry trade	0.39	0.57	−0.88	−6.79
Horizontal IIT	0.03	0.04	−0.02	−0.39
Vertical IIT Type I (VTX/VTM > 1.15)	0.29	0.48	−0.68	−5.41
Vertical IIT Type II (VTX/VTM < 0.85)	0.07	0.05	−0.19	−0.99

[a] Trade between the UK and 27 MID and developing countries in 1995. Net exports of services of labour in each skill level group as a percentage of its apparent consumption requirements. — [b] According to the method defined above in equation (7).

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